Example 4 (pg 212)

Example 7. An 8 × 12 wood beam with E = 1,600,000 psi is used to carry a total uniformly distributed load of 10 kips on a simple span of 16 ft. Find the maximum deflection of the beam.

Example 5 (pg 223)

Example 13. Using Table 5.10 select joists to carry a live load of 40 psf and a dead load of 10 psf on a span of 15 ft 6 in. if the spacing is 16 in. on center.

TABLE 5.10 Maximum Spans for Floor Joists (ft-in.)[a]

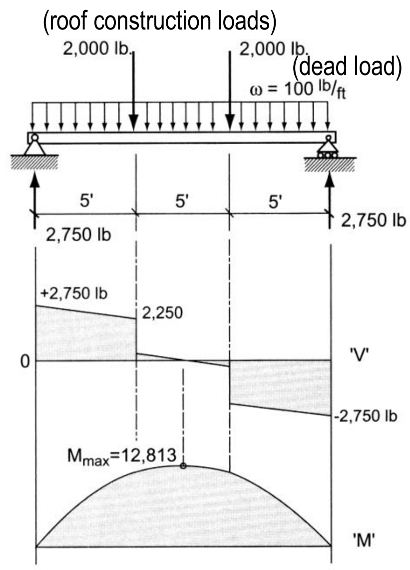
Spacing (in.)	Joist Size 2 × 6	2 × 8	2 × 10	2 × 12
Live load = 40 psf, Dead load = 10 psf, Maximum live-load deflection = L/360				
12	10-9	14-2	17-9	20-7
16	9-9	12-7	15-5	17-10
19.2	9-1	11-6	14-1	16-3
24	8-1	10-3	12-7	14-7
Live load = 40 psf, Dead load = 20 psf, Maximum live-load deflection = L/360				
12	10-6	13-3	16-3	18-10
16	9-1	11-6	14-1	16-3
19.2	8-3	10-6	12-10	14-10
24	7-5	9-50	11-6	13-4

Source: Compiled from data in the *International Building Code* (Ref. 4), with permission of the publisher, International Code Council.

[a] Joists are Douglas fir–larch, No. 2 grade. Assumed maximum available length of single piece is 26 ft.

EXTRA Example

Design a Southern pine No. 1 beam to carry the loads shown (roof beam, no plaster). Assume the beam is supported at each end of by an 8" block wall. F_b = 1500 psi; F_v = 110 psi; $F_{c\perp}$ = 440 psi; E = 1.6 x 10^6 psi; γ = 36.3 lb/ft^3.



SOLUTION:

Because this beam appears to support other beams at the locations of the roof construction loads, we have to assume that this beam is not closely spaced to others and the repetitive use adjustment factor doesn't apply. The load duration factor, C_D, is 1.25 for roof construction loads. The other conditions (like temperature and moisture) must be assumed to be normal (and have values of 1.0). The allowable stresses can be determined from:

$F'_b = C_D F_b$ = (1.25)(1500) = 1875 psi $\quad$ $F'_v = C_D F_v$ = (1.25)(110) = 137.5 psi

$F'_{c\perp} = C_D F_{c\perp}$ = (1.25)(440) = 550 psi

Bending:

$$S_{req'd} \geq \frac{M}{F'_b} = \frac{12{,}813^{lb-ft}(12^{in}/_{ft})}{1875\,psi} = 82.0 in^3$$

Shear:

$$A_{req'd} \geq \frac{3V}{2F'_v} = \frac{3(2,750lb)}{2(137.5psi)} = 30.0in^2$$

Try a 3 x 16. This satisfies both requirements with the least amount of area. (See the 4 x 14, 6 x 10, and 8 x 10.)

(A = 38.13 in^2, S = 96.90 in^3, I_x = 738.9 in^4)

$$w_{self\ wt.} = \gamma A = \frac{36.3\,{}^{lb}\!/\!_{ft^3}(38.13in^2)}{(12\,{}^{in}\!/\!_{ft})^2} = 9.61\,{}^{lb}\!/\!_{ft}$$ which is *<u>additional</u>* dead load!

Because the maximum moment from the additional distributed load is at the same location as the maximum moment from the diagram, we can add them:

$$M_{adjusted} = 12{,}813^{lb-ft} + \frac{9.61\,{}^{lb}\!/\!_{ft}(15ft)^2}{8} = 13{,}083.3^{lb-ft} \quad and \quad S^*_{req'd} \geq \frac{13{,}083.3^{lb-ft}(12\,{}^{in}\!/\!_{ft})}{1875psi} = 83.7in^3$$

The same holds true for the contribution to the shear:

$$V_{adjusted} = 2{,}750lb + \frac{9.61\,{}^{lb}\!/\!_{ft}(15ft)}{2} = 2822.1lb \qquad and \quad A^*_{req'd} \geq \frac{3(2822.1lb)}{2(137.5psi)} = 30.79in^2$$

<u>Check that the section chosen satisfies the new required section modulus and area:</u>

Is $S_{\text{that I have}} \geq S_{\text{that I need}}$? Is 96.90 in^3 ≥ 83.7 in^3? Yes, OK.

Is $A_{\text{that I have}} \geq A_{\text{that I need}}$? Is 38.13 in^2 ≥ 30.79 in^2? Yes, OK.

NOTE: If the area or section that I have is not adequate, I need to choose one that is. This will have a **larger** self weight that must be determined and included in the maximum moment (with the initial maximum). It will make $S^*_{req'd}$ and $A^*_{req'd}$ bigger as well, and the new section properties must be evaluated with respect to these new values.

Deflection:

The total deflection due to dead and live loads must not exceed a limit specified by the building code adopted (for example, the *International Building Code*) or recommended by construction manuals. For a commercial roof beam with no plaster, the usual limits are L/360 for *live load only* and L/240 for *live and dead load*.

$$\Delta_{LL-limit} = \frac{15ft(12\,{}^{in}\!/\!_{ft})}{360} = 0.5in \qquad \Delta_{total-limit} = \frac{15ft(12\,{}^{in}\!/\!_{ft})}{240} = 0.75in$$

<u>Superpositioning</u> (combining or superimposing) of several load conditions can be performed, but **care must be taken** that the deflections calculated for the separate cases to obtain the maximum ***must be deflections at the same location*** in order to be added together:

two symmetrically placed equal point loads (live load): (a is the distance from the supports to the loads)

$$\Delta_{max}(at\ center) = \frac{Pa}{24EI}(3l^2 - 4a^2) = \frac{2000lb(5ft)}{24(1.6x10^6\ psi)(738.9in^4)}(3(15ft)^2 - 4(5ft)^2)(12\,{}^{in}\!/\!_{ft})^3 = 0.35in$$

distributed load (dead load)

$$\Delta_{max}(at\ center) = \frac{5wl^4}{384EI} = \frac{5(100 + 9.61\,{}^{lb}\!/\!_{ft})(15ft)^4(12\,{}^{in}\!/\!_{ft})^3}{384(1.6x10^6\ psi)(738.9in^4)} = 0.11in$$

Is $\Delta_{\text{live that I have}} \leq \Delta_{\text{live-limit}}$? Is 0.35 in ≤ 0.5 in? Yes, OK.

Is $\Delta_{\text{total that I have}} \leq \Delta_{\text{total-limit}}$? Is (0.35 in + 0.11 in) = 0.46 in ≤ 0.75 in? Yes, OK.

Bearing:

Determine if the bearing stress between the beam and the block wall support less than the allowable. If it is not, the beam width must be increased:

$$f_p = \frac{P}{A} = \frac{2822.1lb}{(2.5in)(8in)} = 141.1psi \leq F'_{c\perp} = 550psi$$ so, yes the beam width (2.5 in) is adequate.

USE a 3 x 16.